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# MINING RESEARCH AND INDUSTRIAL ENGINEERING AT BROKEN HILL, AUSTRALIA, AND SELECTIVE OPEN CUT MINING AT MARY KATHLEEN, AUSTRALIA

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# MINING RESEARCH AND INDUSTRIAL ENGINEERING AT BROKEN HILL, AUSTRALIA AND SELECTIVE OPEN CUT MINING AT MARY KATHLEEN, AUSTRALIA

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## MINING RESEARCH AND INDUSTRIAL ENGINEERING AT BROKEN HILL

1. Two associated companies, Zinc Corporation Limited and Broken Hill Consolidated Limited, operate adjoining mines at Broken Hill, New South Wales, producing annually about 700,000 and 600,000 tons respectively. The companies share a common management and services and mining research is not a strictly separate function. One senior official controls mine production, whilst a second controls Underground Services, Mine Planning, Surveying, Geology and Diamond Drilling. Co-ordination between these two groups is achieved at top management level. It is within the Underground Services and Mine Planning functions that mining research is conducted.

2. Mine planning is the process of designing layouts and stoping methods with the object of minimizing the cost of extraction and maximizing ore recovery. In so far as planning represents the application of new thinking, mine planning can be considered to include mining research. Design of mining layouts includes the consideration of such factors as methods of ground support and materials to be used, chute spacing and size related to chute wear and the method to be used as related to the shape and physical characteristics of the orebody. This process demands the consideration of alternatives and the determination of the most economic solution - a research activity.

3. It is with mining equipment and stores that research is largely occupied on these mines. The amount of original research is only small; testing and evaluating various types of equipment already available are the main activities. For this a regular systematic search of technical literature is a necessary activity.

4. An important application of this research technique was the introduction of tungsten carbide tipped drill steel and air-leg mounted rock drills. Eventual use of this equipment was probably inevitable in view of overseas trends, but it fell to mining research to evaluate its application in these mines and to determine the final choice of equipment from available alternatives.

5. Research into underground stores is a continuous process - such items as pully blocks, ropes, hoses and hose couplings, pipes and pipe fittings are constantly under review and alternatives under investigation. The aim is always to obtain maximum economy commensurate with safe operation. A recent example of applied research is a current investigation into the use of ammonium nitrate-fuel oil explosives in small diameter holes drilled for conventional cut and fill stoping.

6. Whilst the types of mining research referred to so far have a specific end-point in the foreseeable future and can thus be evaluated in specific terms, such as increased rate of output or decreased unit cost, there is another aspect of mining research whose end-point cannot be so definite. An example of this is the research into the consolidation of hydraulic stope filling which could achieve considerable advances in mining efficiency and cost. It is not possible at

this stage to consolidat fill economically and research must continue in spite of failure up till now.

7. A further example is the initiation of a research programme in rock mechanics to determine the actual rock stresses underground and to apply the knowledge gained to the design of mine openings so as to minimize the use of timber etc. for ground support. This is basic research with long-range implications.

8. Mining research is aimed at obtaining better efficiency, greater safety and lower costs of production and has both short and long term implications. This can be achieved through improved utilization of men, equipment and materials and by method and equipment studies, establishment and maintenance of standards, and by job evaluation. The Suggestion Scheme provides a means of both fostering and collecting ideas from all employees. Items initiated in the Mining Research Section are often passed over to the Industrial Engineering Section, when the more systematic techniques of Work Study appear desirable.

9. By critical analysis of the methods by which various operations are carried out and of the equipment used, it is generally possible to make improvements which result in the more efficient use of resources of all kinds with consequent savings in costs. A formal technique of analysis known as "Method Study" has been derived for use in this type of work. "Materials Handling" is a special branch of this part of Industrial Engineering and "Cost Analysis" is carried out for the same end.

10. By use of the formal techniques of "Work Measurement" it is possible to establish reasonable or standard times for the performance of various industrial tasks. There are several ways by which work can be measured, each of which has special application to different types of industrial work - the most familiar of these is known as "Time Study" but, similar ends are achieved by use of predetermined motion times, synthesis, analytical estimating, random observations etc. Once standard times for different tasks have been established, it is possible to evolve administrative systems which enable comparison to be made at regular intervals between what is done with what it is possible to do. Indices of efficiency can thus be derived which facilitate the exercise of enlightened control by management.

11. A further use of standard times is in the field of incentive schemes. Once the proper time for a task is known it becomes possible to pay additional wages in equitable proportions to performance by men in excess of standard.

12. By the use of job evaluation it is possible to derive indices for industrial tasks which enable the relative worth of one to be compared to that of another. The availability of these indices is valuable in the derivation of equitable wage and wage incentive schemes.

13. Since Industrial Engineering does its work in all departments of an organization and must be unbiased, it cannot properly belong to any one of them. It is important that it should be separate and report to the top local manager. Of necessity Industrial Engineering staff-members should be carefully chosen for their skill in human relations and their ability to co-operate readily. The Industrial Engineering section itself may be divided into segments with each responsible for

a section of the industrial operation e.g. mining, concentrating, engineering etc., or the section could be divided into functions, some staff becoming expert in methods work, others in standards and others in incentives etc.

14. Examples of the results obtained by these techniques are now described. By use of Method Study and Cost Analysis, it was determined that the most economical way to unload, store and load packaged mine timber on a particular mine was by using a large gantry crane. This resulted in an annual saving of approximately £A20,000. Method Study also revealed an improved method of fabricating pipe hangers for use underground which resulted in a production of 450 hangers per man shift compared with 75 by the original method. By using Time Study it was possible to determine a standard time for the production of a ton of ore from a timber stope. By comparison with what was actually being achieved this allowed management to take action to bring production up to the determined standard. Using Analytical Estimating the standard time for the overhaul of a scraper winch was found to be 40 hours. This knowledge enabled the efficiency of performance of this task to be improved from 37 to 95%.

## SELECTIVE OPEN-CUT MINING AT MARY KATHLEEN, AUSTRALIA

15. The Mary Kathleen ore-body near Mt. Isa, Queensland occurs as a series of discontinuous lenses of radioactive ore in a zone of intense alteration in impure lime and silicate rocks. The workable zone occupies a horizontal area about 700 ft x 700 ft. The ore occurrences vary in thickness from a few inches to more than 200 feet, with ore and waste rock occurring in the ratio of approximately 1 to 1.

16. Early recognition of the complex and irregular nature of the ore lenses led to the decision to operate from a large number of low benches with relatively small equipment. This consists of the following machines. One drilling machine with hard metal bit, three drilling machines with 2¾-inch tungsten carbide bits, one 2½-cu yd electric shovel, three 1½-cu yd diesel shovels, one crawler tracked front end loader, sixteen 15-ton quarry-type trucks, four 185 drawbar h.p. bulldozers, one 100 drawbar h.p. tractor, and one 110 h.p. grader.

17. Using this equipment, an average mining labour force of 82 men produce 1,500,000 tons of material annually, comprising: ore, 460,000 tons, waste separated in selective mining operations, 390,000 tons, and overburden, 650,000 tons.

18. Selective mining is practised because the treatment of the ore is expensive and reagent consumption is independent of the uranium content. There is therefore a strong economic incentive to reduce the amount of waste passing into the treatment plant.

19. Each new bench face, as it is exposed by blasting, is examined by samplers with a modified pocket monitor. This beta-gamma detector has been made unidirectional by fitting a lead shield to screen out the effects of radiation from other sources. The boundaries of ore lenses so established are traced out on the face with white paint lines. Ore is identified by the symbols "A" and "B" for high and low grade ore, and waste by "W". The face is then mapped by a geologist.

20. Only one row of 2¾-inch blast holes is drilled 6 ft behind a face, normally 8 ft apart. These holes are drilled to a depth of 27 ft below the bench and are then radiometrically probed and surveyed. The information so obtained is plotted in plan and section to correlate ore intersections and from these plans a selective blasting pattern is planned. Large blasts of ore are rarely possible; nearly all ore production comes from blasts of 2,000 tons or less.

21. The mine foreman, following a long-range excavation schedule, has certain benches and bench areas available to him at any time for current operations. From these areas the treatment plant must be kept supplied with ore. The mine foreman decides what quantity of ore is required and asks for blasting instructions. These are in the form of instructions to blast a certain group of holes and may call for firing some holes part-depth only, or for leaving some gaps in a row of holes, or both. Selective blasting frequently results in ragged or scalloped faces in which case the remainder of the face usually is subsequently broken with toe-hole drilling and blasting.

22. After every primary blast on the ore benches, the broken rock is inspected by a sampler with a geiger counter. Any large lumps of included ore in a waste pile, or waste in an ore pile - more usually the latter - are marked distinctively for removal by a mobile crane and wire rope slings or nip chains. Working two shifts the crane removes a daily average of 150 tons of waste which would otherwise go to the treatment plant.

23. All material from ore benches, as it leaves the open cut, passes through a discriminator. This is a combined weighbridge and radiometric grade assessment station. A loaded Euclid truck halts on the weighbridge platform and its load is scanned by a battery of six geiger tubes shielded from outside influence and fixed to the walls and roof of the building. Impulses from the tubes are integrated and the result read on a dial. The loaded vehicle is then directed by the discriminator operator to its destination, i.e., treatment plant, waste pile, or either of the two stockpiles of marginal ore.

24. Ore delivered to the treatment plant is crushed and screened in order to separate pieces larger than 3 in. and less than 8 in in size. These pieces are sorted into ore and waste fractions by four units, each of which works in the following manner. The lumps of rock are fed from a feeder cone which discharges them in a single line on to a belt conveyor. They are then discharged individually from the belt and fall in front of a scintillometer head which measures the radioactivity of each piece in relation to its area.

25. Rock pieces with a value above a predetermined setting are allowed to fall freely on to a conveyor and join the fine material which did not pass through the sorter. Waste rock pieces with a lesser value are deflected from their free-falling trajectory line by a compressed air blast from three 1¼-in tubes located 14 in below the scintillometer head, and fall on to a conveyor belt for delivery to the waste bin. The average radioactivity of rock discarded by the sorter is very low. This sorting method is applicable in principle to properties of rock other than radioactivity e.g. colour, but application of the principle is difficult.

26. The thanks of the Bureau of Mineral Resources are expressed to the managements of the companies concerned who supplied the information used in this article.

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